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POTATO CULTURE.

BY

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UNITED STATES DEPARTMENT OF AGRICULTURE,
OFFICE OF EXPERIMENT STATIONS,
Washington, D. C., December 4, 1895.

SIR: I have the honor to transmit herewith for publication as a Farmers' Bulletin an article on potatoes, with especial reference to their culture and the amount and size of seed, prepared in this Office by Mr. J. F. Duggar. Much valuable work on this subject has been done by the agricultural experiment stations of this country, and on certain phases, at least, quite definite conclusions have been reached as to the best methods to pursue. In the preparation of this bulletin the work of the experiment stations has been thoroughly reviewed and summarized and in addition the current literature bearing on the subject has been gone over.

Respectfully,

A. C. TRUE,
Director.

Hon. J. STERLING MORTON,
Secretary of Agriculture.

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POTATO CULTURE.

INTRODUCTION.

This bulletin is not intended as a complete treatise on potato culture. The discussion of varieties and manuring has been merely touched upon, the importance and intricacy of these subjects meriting fuller treatment in a separate publication. But special attention has been given to the most profitable amount of seed, and as factors in this question the proper distance between seed pieces and other closely related subjects have been briefly treated. Some other cultural questions have also been considered. In regard to fungous diseases the reader is referred to Farmers' Bulletin No. 15 of this Department, "Some destructive potato diseases." Methods of combating insect enemies are treated in Farmers' Bulletin No. 19, "Important insecticides."

The potato (*Solanum tuberosum*) is a native of America, though it is widely known as the Irish potato because of its general use in Ireland. Aside from its universal cultivation in gardens it constitutes an important field crop over the greater portion of the country. The value of the annual potato crop of the United States is approximately $100,000,000. Yields of 250 or 300 bushels per acre are frequently obtained over large areas, and there are not a few records of more than 500 bushels. These encouraging figures stand in bold relief against those giving the average yield for the United States, which is less than 100 bushels per acre.

SOIL AND ROTATION.

The potato is grown in every State and Territory, and naturally on a great variety of soils. Indeed, it has been grown on nearly every class of soils, but this fact does not minimize the importance of selecting for the potato the kind of soil best adapted to it. The ideal soil for this crop should be one so light as to offer no great resistance to the enlargement of the tubers, so supplied with organic matter as to be rather moist without being wet, and so rich as to furnish an unfailing supply of fertilizing ingredients. A rich, sandy loam abundantly supplied with organic matter and naturally well drained is preferable. Stiffer soils may be rendered suitable for the potato by drainage and by the incorporation of farm manures, or better by plowing under green crops. Very heavy clay should be avoided if the farm contains

any lighter soil. Recently cleared ground suits the potato. Sandy soils, if not too subject to drought, may be fitted for this plant by the addition of organic matter. It is claimed that potatoes grown on sandy land are of better quality than those grown on stiffer soil.

The potato requires a rich soil, but even more important than natural fertility is a proper mechanical condition of the soil. Artificial fertilizers may be substituted in part for natural fertility, but they are effective only when the soil is in such a condition as to furnish a constant supply of water. The potato should have the best soil on the farm, since it is more exacting in this respect than the other staple crops and since the product of an acre is generally of greater value.

The success of the potato is largely dependent on the crops preceding it in the rotation. If clover, cowpeas, or other leguminous plant is grown just preceding potatoes, its stubble furnishes organic matter and adds to the store of available nitrogen in the soil. Corn after sod frequently precedes potatoes, and this is generally regarded as the best rotation.

Rye is sometimes sown in late summer or fall and plowed under so as to lighten a heavy soil. Buckwheat and other plants have also been used for the same purpose. On light soils and in rather mild climates, crimson clover for green manuring may advantageously take the place of rye where early planting of potatoes is not specially desirable. One year, or at most two years, is as long as a field should be devoted to continuous potato culture, although this crop is sometimes grown for more than two years in succession on the same land. This latter course taxes heavily the fertility of the soil and necessitates liberal manuring; moreover it involves considerable risk of injury from fungous diseases, especially from potato scab. A clean crop of potatoes can not, as a rule, be grown on land which in the preceding year produced scabby tubers. The germs of the disease once in the soil must be starved out by growing on the infected field other crops, such as grass or grain, for several years. In certain localities in the central part of the United States and elsewhere the following three years' rotation has given highly satisfactory results on farms where potatoes are extensively grown: Fall wheat, in which clover is seeded in spring; second year, clover, plowed under in fall or winter; and third year, potatoes. In some localities the uncertainty in obtaining a catch of clover renders this rotation inexpedient.

Detailed directions for the preparation of one class of soils would not apply to others, hence it can only be said that preparation should be deep and thorough, and that unnecessary compacting of the soil should be avoided. Plowing can scarcely be too deep, provided that much of the subsoil is not brought to the surface; when practicable, the depth should be gradually increased from year to year. Though the tubers are usually formed within 6 inches of the surface of the ground, the roots feed deeper. At the Utah Station a very large proportion of

potato roots were found 12 inches below the surface. At the New York State Station potato roots penetrated to a depth of 34 inches. Girard, in France, measured single roots nearly 6 feet long growing on rich soil, deeply prepared. (See fig. 1, p. 7.)

Practical experience, as well as the extent of the distribution of potato roots in the soil, emphasize the importance of deep and thorough preparation of the soil for this crop. Whether fall plowing is advisable depends on a variety of local considerations. In general in a mild climate fall plowing of light land exposes it to leaching; on the other hand, fall plowing is sometimes necessary, as, for example, when a field is badly infested with injurious insects.

MANURING.

The potato requires liberal manuring. Barnyard manure usually affords a large increase in the crop, for not only does it supply nitrogen, phosphoric acid, and potash, but it improves the mechanical condition of the soil. However, its direct application to the potato affords conditions favorable to potato diseases, and thus injures the quality of the crop. For this reason the best practice is to apply barnyard manure to corn or grass the year before potatoes are grown. If it is considered necessary to apply it directly to the potato crop it should first be well rotted.

If for several years before potatoes are planted the land has been properly manured with farm manures or with green crops plowed under, commercial fertilizers can be advantageously used on most soils. Generally a complete fertilizer should be used, i. e., one which contains nitrogen, phosphoric acid, and potash. The farmer is justified in supplying all three of these fertilizing ingredients unless by previous tests he has learned that on his soil a certain one of them can be safely omitted.

Of nitrogenous fertilizers, one of the best for potatoes is the quick-acting nitrate of soda. Of phosphatic fertilizers, superphosphate is preferred. Among potash fertilizers the sulphate of potash has been found to afford a better quality of potato than kainit and muriate of potash. Ashes are extensively and effectively used to supply potash to potatoes.

Numerous special potato fertilizers are on the market, their chief peculiarity consisting in a higher percentage of potash than is contained in the ordinary brands of mixed commercial fertilizers. American experiments indicate that a fertilizer mixture for potatoes should contain a high percentage of potash.

Since the proper position of fertilizers with reference to the seed pieces doubtless depends on the character of season, soil, and manure, no general rule can now be given further than to caution the reader against applying the fertilizer in immediate contact with the seed piece.

VARIETIES.

The following are among the most widely grown varieties: *Early*, Early Ohio, Early Rose, Beauty of Hebron, and Triumph. *Medium and late*, Burbank, Rural New Yorker No. 2, Empire State, Mammoth Pearl, White Star, and Dakota Red.

These are standard varieties, and though not necessarily the best they seem to have given general satisfaction.

PLANTING.

GENERAL DIRECTIONS.

The rows should be laid off as close together as practicable without interfering with horse cultivation. Generally the seed pieces should be dropped in furrows made in the level field and not on ridges. However, low ridges are advantageous for an early crop and on poorly-drained land. In covering the seed pieces, whether they are planted flat or on ridges, it is well to leave a small, sharp ridge marking the line of the row. In some localities, however, where excessive moisture is not feared the opening furrows are only partially filled after planting, leaving a depression along the row to be filled by the use of the smoothing harrow or other implement. In planting late in the season this course is sometimes advisable.

The pieces may be dropped by hand in the open furrow, or a potato planter may be used, dropping and covering the seed pieces at one operation. There are several potato planters that do very satisfactory work, but their cost restricts their use to those who plant a large acreage in potatoes or to cases where several farmers can use one together. Their more extended use is perhaps desirable, since they save a considerable amount of labor and enable the potato grower to take full advantage of even a brief period of favorable weather at planting time regardless of scarcity of labor.

There is not sufficient evidence now available to determine whether there is any difference in yield due to the cut surface of the set being placed upward or downward when planted. Probably there is no loss in letting the seed pieces fall as they will from the planter or from the hand.

In the preparation of the ground and in planting, the earth along the line of the row should be compacted as little as possible consistent with thorough work, and hence the team should be made to walk between the rows whenever possible instead of along the drill. There is a simple potato coverer constructed somewhat like a triangular snow plow, with the wide end forward and a portion of the point or apex cut away so as to leave a narrow opening at the rear. No special implement, however, is required for this purpose.

TIME OF PLANTING.

Each community is the best judge of the proper date for planting. Where potatoes are grown for the early market the aim is to plant as early as possible, without subjecting the young plants to severe cold. The crop should be planted at such a date as to bring the stage of growth during which the tubers are rapidly developing at a time when there is ordinarily an adequate supply of moisture. The month when dry weather is most certain varies with the locality, and each potato grower should so time his planting as to be least affected by drought. Where the growing season is long the crop that is to be stored over winter should be planted very late, so that it may remain in the ground until cool weather. On the other hand, where the season is short, late varieties should be planted in time to ripen before frost.

FIG. 1.—Entire plant, showing root system.

DEPTH OF PLANTING.

The roots of a young potato plant grow, not directly from the seed piece, but from the underground joints or nodes of the stem. From these underground nodes also grow the short stems which bear the tubers at their extremities. (See fig. 1.) Hence the seed pieces should be placed deep enough in the soil to permit several of these joints to form below the surface, so as to afford room for an ample supply of roots and tuber-bearing stems to grow.

Many experiments have been made to ascertain the best depth for planting. The results, with some exceptions, favor planting not less

than 4 inches deep. The favorable effects of deep planting were especially marked on well-prepared, friable soil and in dry seasons.

Very deep planting is open to objection because of the increased labor of harvesting and the danger of a deficient stand when weather conditions are unfavorable. Very shallow planting reduces the yield and injures the quality of the crop.

THE RURAL TRENCH SYSTEM.

The Rural trench system consists in planting the pieces in deep trenches made either by the spade or plow. It differs from other methods chiefly in the greater care taken to secure a thorough preparation beneath the potato. To this end after deep and wide trenches are formed the bottoms are pulverized and a portion of the fine earth which was removed in forming the trenches is raked back into the furrows, so that the set is planted on top of a layer of fine, well prepared soil and at a depth of 4 to 6 inches. Fertilizers are placed near the seed pieces above or below, but separated from them by a thin layer of soil. The trenches are then filled and level culture is practiced.

TIME TO CUT SEED POTATOES.

At least three American experiment stations have conducted tests to learn the effect of cutting seed potatoes several days or weeks in advance of planting. The results varied somewhat according to the length of time that the cut sets remained unplanted, but on the whole indicated no marked difference in productiveness between planting freshly cut pieces and those that had been cut for a week or less.

The investigations of Kraus and of Wollny in Germany led to the conclusion that a slight wilting of the seed pieces increased the yield on moist soils and in wet seasons, but reduced it on soils not retentive of water and in dry seasons.

On the whole it appears that the storing of cut pieces for several days, which sometimes becomes necessary, is attended with no great disadvantages. Of course due care should be taken in such instances to prevent heating, and it may be well to dust the cuttings with gypsum (land plaster) to prevent excessive wilting.

CHANGE OF SEED.

To test the effect on the yield of using seed potatoes from different localities, several varieties of potatoes grown in Vermont and in Maryland were planted in both States. The seed grown in Vermont gave larger yields both in Vermont and in Maryland than seed grown in Maryland.

It has been found advantageous to change seed potatoes every few years, but from the small amount of definite experimental data now available we believe no final conclusion can be drawn as to the effect

of the practice. To make the change, tubers of the desired strain may be sent to a grower at a distance, and after two years' culture under new conditions the stock may be brought back to its original home.

A common practice in the regions where a second crop can be grown on the same land in the same year is to plant in the spring a small area with Northern seed potatoes, replanting the resulting tubers in July or August, and using the crop produced in the fall for the main spring planting. By this course seed is renewed frequently without sacrificing any of the advantages resulting from the use of second-crop seed stock, such as freedom from sprouting, etc.

SEED END V. STEM END.

When potatoes are cut in half through their smaller diameter we have a seed or bud end more or less crowded with eyes and a stem or butt end on which there are few eyes (see fig. 2, p. 14.) The experiments to determine the relative values of cuttings from the stem end and from the seed end of the tuber have been numerous. The majority of these showed that the yield was greater when the seed end was used. The superior productiveness of the seed end as compared with the stem end was maintained, whether the halves of the potato, the thirds, or smaller cuttings were employed.

In a few instances, however, the results suggest that the general superiority of the seed end may not be maintained with some varieties and with immature seed tubers.

EFFECT OF SPROUTING.

The growth of sprouts before planting is made at the expense of the tubers from which they draw their support. Hence if these shoots are rubbed off before planting there is a total loss of the nutriment contained in them. Moreover, numerous weak shoots grow from the injured eye. To prevent these evil consequences of premature sprouting, seed potatoes are stored in a dark, dry, cool place. In spite of all precautions the tubers sometimes sprout; but when practicable only potatoes that have not sprouted should be selected for planting.

If the eyes appear dormant in spring, seed potatoes may be exposed to the light and warmth for a few days before planting so as to promote germination and prompt growth. If long exposed, sprouts will form and careful cutting and planting by hand become necessary so as to avoid breaking off these sprouts.

QUANTITY OF SEED POTATOES PER ACRE.

A bushel of potatoes (60 pounds) may contain 240 quarter-pound tubers. When the seed pieces are planted a foot apart in 3-foot rows an acre requires 14,520 sets. When tubers averaging 4 ounces are employed an acre requires at these distances 60 bushels for planting whole potatoes, 30 bushels when halves are used, and 15 bushels when

quarters are planted. In a number of tests the amount of seed cut to 2 eyes, spaced 1 by 3 feet, averaged 13 bushels per acre, the usual range being from 10 to 14 bushels. In 18 experiments with many varieties the average amount of seed cut to single eyes was at these distances 6.3 bushels per acre, the usual range being from 5 to 7 bushels, though the varieties with large tubers bearing few eyes required considerably more seed.

Results which follow in these pages suggest that it is generally advisable to plant at least 15 to 30 bushels per acre.

SIZE OF SEED PIECES.

In the size of the seed piece planted the practice of different farmers varies widely, some advocating a liberal use of seed and others claiming equally good results from small cuttings. To aid in settling this question the State agricultural experiment stations have made numerous tests of seed pieces of different sizes. Taken separately these experiments show a certain amount of divergence in results, as might naturally be expected of tests conducted under widely different conditions. However, the majority of these tests, and especially the figures expressing the average results of all available American experiments, may be safely taken as indications of what the farmer, under ordinary conditions, will generally, but not always, obtain.

The effect of size of seed pieces on yield of crop will be treated here under three distinct heads, (1) on the total yield; (2) on the gross yield of salable potatoes; and (3) on the net yield of salable potatoes, i. e., after deducting the amount of seed planted.

EFFECT ON TOTAL YIELD.

In making up the averages below it was found practicable to use the results of 19 tests of single eyes *v.* 2-eye pieces, 4 tests of 2-eye cuttings *v.* quarters, 17 comparisons of quarters and halves, and 44 tests of halves *v.* whole potatoes. The results of other experiments less completely reported were used for the purpose of corroboration.

The following table shows the average results of these tests, including potatoes of all sizes:

Average differences per acre in total yields from different seed pieces.

	Bushels.	Per cent.
Excess from use of—		
2-eye pieces over 1-eye pieces	26	21
Quarters over 2-eye pieces	15	16
Halves over quarters	24	18
Whole tubers over halves	31	18

If we compare all the total yields with the total yield produced by single eyes we have an increase of 21 per cent for 2-eye pieces, 41 per cent for quarters, 67 per cent for halves, and 96 per cent for entire

tubers. The total yield resulting from planting whole potatoes is practically double that obtained by planting single eyes.

Thus far we have considered only the total yield, i. e., large and small potatoes, and have found that the total yield increases somewhat uniformly as the size of the seed piece is increased. Hence, if it is the aim simply to secure an enormous yield without much regard to expense, in contests for prizes, etc., a lavish use of seed is justifiable. The farmer and gardener, however, have to consider other factors than the total yield, for a heavy crop may consist very largely of tubers too small for the market, or the great expenditures for seed when large pieces are planted may more than counterbalance the increased yield. Before noting the gross and net yields of large or salable tubers, resulting from seed pieces of different sizes, we may consider the causes inducing a somewhat regular increase in total yield accompanying the use of larger seed pieces.

Several causes operate to increase the yield when large seed pieces are planted. The larger the cutting the greater generally the number of eyes and the number of stalks. The young shoot, before it develops a strong system of feeding roots, is dependent for nutriment on the material stored up in the seed piece; hence the more abundant this supply the more vigorous the growth of the plant, and this increased luxuriance is not confined to the early stages of growth, but is marked throughout the growing season. Investigation has shown that severing the connection between the seed piece and the growing vine, even after the latter is thoroughly rooted, reduces the yield of potatoes.

The danger of partial or entire failure resulting from an imperfect stand is much greater with small cuttings than with large seed pieces. The small pieces with extensive cut surfaces are liable to perish should the season be unfavorable, either through excessive moisture or drought. The sprouts from small cuttings being weaker reach the surface with difficulty, or fail entirely on soil not properly prepared.

EFFECT ON GROSS SALABLE YIELD.

By averaging the results of the experiments referred to above, we find that the actual increase in the potatoes of salable size due to using larger seed pieces was as follows:

Average differences per acre in gross salable yields from different seed pieces.

	Bushels.	Per cent.
Excess from use of—		
2-eye pieces over 1-eye pieces	23	21
Quarters over 2 eye pieces	10	15
Halves over quarters	15	15
Whole tubers over halves	14	10

Every increase in the size of the seed pieces was followed by an increased gross salable yield.

EFFECT ON NET SALABLE CROP.

Before concluding that the largest seed pieces are the most profitable it becomes necessary to deduct from the crop the amount of seed planted. It is plain that the increased amount of seed potatoes required when larger pieces are used may more than counterbalance the increase in yield obtained.

The true test of profit is the market value of the crop produced, less the cost of seed planted. Should the quantity of seed potatoes used be subtracted from the total yield of large and small potatoes or from the salable crop? If small or unsalable seed potatoes are planted, then the former course is the proper one, but since large or medium tubers (either entire or cut) are generally selected for seed purposes, it seems best to subtract the seed from the salable crop, thus ascertaining the net salable yield.

The following table shows the actual average results for the net salable yield; that is, the crop after deducting the small potatoes and the seed used:

Average differences per acre in net salable yield from different seed pieces.

	Bushels.	Per cent.
Excess from use of—		
2-eye pieces over 1-eye pieces	15.0	14
Quarters over 2-eye pieces	7.0	15
Halves over quarters	5.0	6
Halves over whole tubers	8.5	8

The amount of the net salable crop rose with the increase in the size of the cutting employed, but when the whole potato was planted the figures declined on account of the large amount of seed potatoes which had to be deducted. The above figures indicate a very slight advantage in planting halves rather than quarters when the price of seed and of crop produced are the same. As a matter of fact, spring prices are usually somewhat higher than fall prices. A high price for seed potatoes may make it profitable to plant smaller pieces (as, for example, quarters) than would be economical where seed and crop command the same price per bushel.

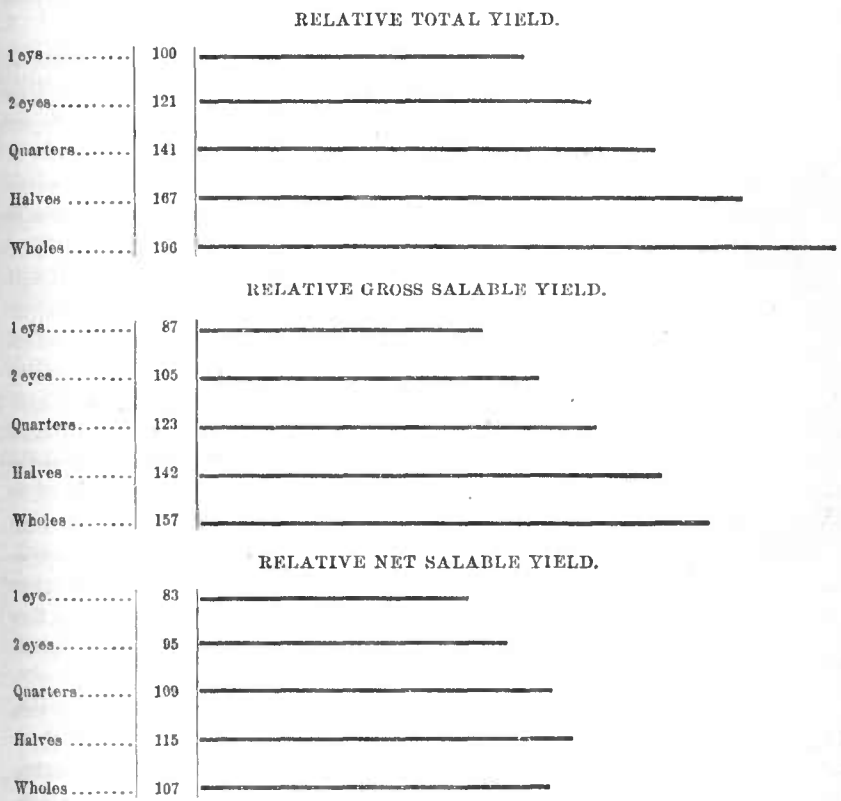
GENERAL CONSIDERATIONS ON THE AMOUNT OF SEED POTATOES.

In the following diagram 100 represents the total yield from planting single eyes. The figures may be read as bushels per acre, if it is constantly borne in mind that we are talking about soils of such character as to average 100 bushels of large and small potatoes per acre when planted with 1-eye pieces.

The first group answers the question, "What size of seed piece generally affords the largest yield of large and small potatoes?" The second group answers the query: "What size of seed piece generally

gives the greatest yield exclusive of small potatoes?" The third group offers an answer to a still more important question: "What size of seed piece generally produces the largest yield after deducting both the small potatoes and the amount of seed planted?"

Yield from planting different seed pieces, assuming 100 as the total yield from single eyes.



Taking as the correct measure of profit the yield of salable potatoes less the amount of seed used we see by the third section of the diagram that with seed and crop at the same price per bushel it was more profitable in these tests to plant halves than smaller cuttings and whole potatoes.

If we take account of the yield of small potatoes the advantage of large seed pieces is even greater than the figures in the last section of the diagram would indicate, for the yield of small potatoes is greater with large than with small seed pieces. Where large quantities of small potatoes can be profitably utilized, as for example as seed for the second crop, the potato planter may therefore use quite large seed pieces with advantage.

On the other hand, the higher price of potatoes in spring than in fall is an argument in favor of planting quarters rather than halves or

whole tubers. A number of investigators have noted that large seed pieces (either large cuttings or entire potatoes) afford an earlier crop than very small cuttings, a matter of much interest to growers of early potatoes. However, some growers have reported that uncut potatoes germinate more slowly than large cuttings. Most of those who raise potatoes for the early market use large cuttings rather than whole potatoes.

In this connection it may be said that the seed-end half gives an earlier crop than the other half. This suggests the expediency of cutting a potato lengthwise when halves or quarters are to be planted, thus securing on each piece one or more of the eyes which germinate first. Another advantage of cutting lengthwise is that it insures a more even distribution of the eyes on the several pieces. Of course this system is not practicable when very small cuttings are to be made from long, slender potatoes, since the large amount of exposed surface would render the long pieces susceptible to injury both from moisture and dryness.

FIG. 2.—Tuber, showing arrangement and order of sprouting of eyes.

If it is desired to cut the potato into small pieces the operator should begin at the stem end, and the pieces should be cut in a compact shape and of as nearly equal size as is practicable without leaving any piece entirely devoid of eyes. There are special implements for cutting potatoes, and their use is reported as enabling a man to cut four or five times as many bushels of seed per day as by hand. The character of the work is said to be satisfactory.

No definite rule can be given as to the best size of seed piece, for this depends somewhat on the distance between the hills and on the character of the soil and season. Another important factor in determining the proper amount of seed is variety. Some varieties are able to produce a crop almost as large from small cuttings as from large pieces. Thus, in several experiments, the variety Clark No. 1 has given indications of this capacity to produce well even with light seeding.

SIZE OF SEED TUBERS.

A study of more than a hundred experiments testing the relative values of large, medium, and small uncut tubers confirms the general law that an increase in the weight of seed planted affords an increase in the total crop. The yield of salable potatoes increases less rapidly than the total yield. With whole potatoes as seed the salable yield reached its extreme upward limit in one test when tubers weighing about half a pound were planted; in another when those weighing 4½ ounces were employed. The limit of profitable increase was reached

with tubers weighing 4½ and 3 ounces, respectively. The size of seed tubers selected becomes a matter of importance when they are to be cut, for we have seen that the heavier the cutting the larger the total yield, and seed tubers for cutting should be of such size that their halves, quarters, or other divisions shall not be extremely small.

CAN SMALL POTATOES BE PROFITABLY USED FOR PLANTING?

Whether or not to use uncut small potatoes for seed is an important question on which farmers are divided. Some present the plausible argument that the use of undersized potatoes results in degeneration. If this claim is based on the results of experience it should determine practice, but if the conclusion is simply a generalization based on the fact that large seeds usually give best results the reasoning is defective, and the question remains open. The potato tuber is not a seed, but an underground stem, and the relations existing between seeds and their progeny do not necessarily exist between a tuber and its descendants. Others hold that potatoes just below marketable size, if shapely and sufficiently mature, may be used without serious deterioration; and that for economic reasons their use is especially desirable, because if not planted or used at home they must be lost or fed to stock, for which purpose their value is usually smaller than the market price.

The result of tests at a number of experiment stations have uniformly indicated that small tubers uncut can be used for seed purposes without detriment to the succeeding crop. It may still be urged, however, that the choice of small seed year after year will result in degeneration. On this question the information is meager, but two experiments, extending over four and eight years, respectively, have been reported in which no degeneration resulting from the continued use of small potatoes from the preceding crop was apparent.

Although the evidence seems fairly conclusive that small uncut seed potatoes may sometimes be used with profit, we can not advise that small seed tubers be selected year after year from a crop which has been grown from small potatoes.

Girard's investigations in France justified the usual practice of the most prominent agriculturists and horticulturists in carefully selecting seed potatoes. By selecting for several generations average-sized tubers from the best hills he effected a considerable improvement in productiveness. To ascertain the best hills by digging each is exceedingly laborious, but Girard found that the best hills in an evenly manured field containing only one variety were those in which the vines were most vigorous. Selection was thus rendered easy by means of stakes placed beside the luxuriant plants. This correspondence between the vigor of vegetation and yield of tubers has been frequently noted at the State agricultural experiment stations, especially with seed pieces of different sizes, in which case the growth of vines is

in proportion to the size of the seed piece planted. American experiments indicate some advantage in selecting seed tubers from the most productive hills.

Potatoes of irregular shape and injured tubers should be rejected as unfit for planting.

NUMBER OF EYES AND WEIGHT PER SET.

Many potato growers cut tubers into pieces containing one, two, or more eyes, laying greater stress on the number of eyes than on the size of the cutting. Extensive experiments at the Indiana Station and elsewhere prove that of the two factors, number of eyes and weight of piece, the latter is the more important. Of course it is desirable that each piece, whether large or small, should contain at least one eye, and it has been generally profitable for it to be of such size as to contain at least several eyes; but whether it has one or many eyes it is important that the seed piece be heavy enough to furnish abundant nutriment to the shoots which spring from it. A single eye may give rise to several stalks, for each eye is a compound bud, or cluster of buds. An eye can be bisected, and each half may then grow successfully if it is not a victim to dryness or decay, to which its exposed condition subjects it.

In one series of experiments it was found that the number of stalks growing in a hill was less dependent on the number of eyes than on the size of the seed piece, whether cut or entire. In general, as the number of eyes per piece increased each eye became less prolific in sending up stalks, so that there was less crowding of stalks where large seed pieces with many eyes were used than would be expected from the large number of eyes planted. After numerous experiments touching on almost every aspect of this subject the investigator advised that tubers be cut so as to make each piece of a constant size or weight, whatever the number of eyes that might fall to its share.

NUMBER OF CUTTINGS PER HILL.

A custom not uncommon among those who plant small cuttings is to drop two pieces in each hill. They usually get a larger yield by so doing than by planting single pieces, the increase generally, though not always, being sufficient to pay for the excess of seed. This does not prove the practice profitable, for better results may be secured by planting a single piece weighing as much as the combined weight of the two pieces which would have been dropped in one hill. Thus the labor of cutting is considerably reduced and, what is more important, larger pieces improve the chances of getting a good stand in an unfavorable season, because they have less exposed surface than two small pieces of equivalent weight, hence are less liable to dry out excessively when drought follows planting; they are also better able to resist rotting if wet weather prevails.

NUMBER OF STALKS PER HILL.

The most common objection urged against planting large seed pieces is, next to the expense, the danger of having the hills so crowded with stalks, and consequently with tubers, that a large proportion of the potatoes never develop to marketable size. This objection is probably valid for entire tubers, and also for halves planted very close in the row. The evidence available does not permit us to conclude that in the case of quarters used as seed there results any injurious crowding, and it may be questioned whether halves give rise to this trouble when planted under favorable conditions and at considerable distance apart.

The number of stalks that can be advantageously grown in each hill varies greatly with variety, season, soil, and distance apart. At the Indiana Station it was found that when uncut tubers of 1 to 5 ounces were planted in hills 3 feet apart the gross yield of large potatoes and the net yield of large potatoes increased with every increase in the number of stalks per hill up to 9 stalks for Burbank and 8 stalks for Beauty of Hebron, growing in both cases from tubers weighing 4½ ounces. Eight stalks per hill would probably be excessive for distances less than 3 feet each way. In experiments in Maine, extending over several years, 6 stalks per hill gave larger yields than 4 or 2 stalks, the amount of seed planted being the same in each case.

As to the effects of thinning the stalks, recorded experiments are inconclusive, and with ordinary seed pieces it appears to be unnecessary.

DISTANCE BETWEEN PLANTS.

In deciding on the proper distance at which to plant potatoes it is necessary to take into consideration the size of the seed piece that is to be employed. In general, small seed pieces should be planted close and the distance allotted to each hill should be greater as the weight of the piece is increased. Close planting for small cuttings is best attained, not by narrowing the row to less than about 2½ or 3 feet (for if the distance is much less horse cultivation becomes difficult), but by planting the seed pieces close together in the row.

To frame a general rule giving best distances for seed pieces of different sizes is plainly impossible, for the distance at which the largest yields is obtained depends also on the variety, the season, the soil, and the fertilizers. However, the results of some of the investigations covering this matter afford help in deciding on the proper distance under varying conditions.

It has been shown that if very small cuttings are used, and if the soil is fertile, the distance can be reduced to 6 or 9 inches without sacrificing the yield, provided the season happens to be favorable, but this is not generally advisable.

On rich soil cuttings of considerable size can be advantageously planted as close as 12 inches.

Checking effects a saving of labor in cultivation, and also in planting and harvesting, when these latter operations are performed by hand, hence expensive labor and the absence of machines for planting and harvesting the crop are conditions in favor of checking. For planting in checks a variety can be chosen which makes a large growth of vines and which forms many tubers in each hill, thus more completely utilizing the space at its disposal than could a variety with small vines and few tubers. In checking there is danger on rich soil that some of the tubers may grow to an objectionable size. Potato growers in attempting to obtain a phenomenal yield, as in contests for prizes, almost universally plant in drills rather than in hills, and place the seed pieces from 8 to 15 inches apart.

The advocates of planting in drills claim that by this method a larger yield can be obtained, and experience seems to confirm the correctness of this view. The few experiments that have been made on this question are not entirely conclusive, though the majority of them favor drills.

Although no fixed rule regarding distance of planting can be given, the following general considerations are widely applicable:

(1) For maximum yield of salable potatoes plant in rows as narrow as can be conveniently cultivated.

(2) Crowd small seed pieces close together in the row, increasing the distance with every increase in the size of the seed piece; avoid on the one hand such close planting as to greatly reduce the average weight of the tubers, and on the other such wide spacing as to leave any considerable portion of the soil unshaded by the full-grown vines.

(3) As a rule the richer the land the less the required distance between sets.

(4) Varieties with strong growth of vines or which set many tubers in a hill should have greater distance between plants than is necessary with less vigorous varieties.

CULTIVATION.

Soon after planting, and again just as the young plants are beginning to appear above ground, the field should be harrowed, inclining the teeth of the harrow backward. This is a cheap method of cultivation, since a wide space is covered. It is also effective in destroying small weeds, in leveling the ridges left in planting, in preventing the formation of a surface crust, and in keeping the land covered with a mulch of dry earth, thus conserving moisture within the soil below. Subsequent cultivation should be frequent so as to accomplish these same ends. Almost any pattern of cultivator may be used provided it is made to do shallow work. However, if the ground has become packed the first cultivation may be deeper. Experience and exact experiments generally favor flat or nearly flat cultivation. Excessive hilling during cultivation intensifies the injurious effects of dry weather. It also results in breaking many of the feeding roots between the rows. The

frequent use of the cultivator should be substituted as far as possible for hoeing. If a severe frost is apprehended soon after the plants come up the tops should be covered by throwing a furrow to each row.

MULCHING.

While mulching with hay, straw, leaves, or other litter frequently increases the yield and is specially valuable in tiding over a season of drought, it is not generally practicable on farms where potatoes are grown on a large scale. Its place is in the garden rather than in the field. It is a substitute for cultivation, and it is generally cheaper to maintain a soil mulch by frequent cultivation than to apply litter. If a mulch is employed it can be applied over the entire surface or in the furrow above the seed pieces, or between the rows. Mulching in the furrow is not commended by the results of tests in Colorado, Louisiana, and Michigan. In striving for a large yield, with little regard to cost, or to insure against drought, mulching is useful.

Material intended to serve as a mulch should first be exposed to the weather so as to cause the sprouting of any seed it may contain. It is better to apply a mulch after potato plants have made some growth, as an earlier application may result in smothering some plants and in injury from late frosts.

HARVESTING AND STORING.

The death of the vines is the signal for digging the main crop. For the early market potato growers do not wait for this, but are governed by the size of the tubers. As long as any portion of the vine is green the tubers can continue to grow. At the Vermont Station White Star potatoes, planted May 20, yielded 163 bushels per acre of merchantable potatoes when dug August 22; 234 bushels September 1; 303 bushels September 12, and 353 bushels September 22. More than one-third of the merchantable crop was made after September 1. At the above dates the average size of all tubers was, respectively, 3.7, 4.4, 5.2, and 5.7 ounces, respectively. These figures show the importance of protecting the foliage from the late blight by spraying, and they also afford some data as to the rate at which potatoes develop late in the season.

In gardens very early potatoes are sometimes obtained by carefully removing a few of the larger tubers from the growing plant, replacing the soil and allowing the smaller potatoes to continue growing ("grabbling"). Experiments conducted in Germany by Wollny and Nobbe, and in Austria by Leydhecker showed little or no loss as a result of this operation carefully done. The large amount of labor required prohibits "grabbling" except when early potatoes are selling at a price very much higher than can be expected from the later crop.

In harvesting a large area a high-priced potato digger is frequently used; hand digging with a four-tined fork is probably the best method on small areas, though many make use of a potato hoe or of a plow.

Careful handling always pays, and extreme carefulness is necessary, especially with the early crop, to prevent injury to the tender skin of the immature potatoes.

In harvesting, as well as in storage, potatoes should be exposed to light as little as possible. In storing potatoes a low temperature is required. The potato tuber is uninjured by a temperature of 33° F., and one authority gives the freezing temperature of potatoes 30.2° F. Warmth favors sprouting, which injures potatoes both for planting and eating.

SECOND-CROP POTATOES.

In most of the territory south of Maryland, Kentucky, and Kansas two crops of potatoes are frequently grown in one year on the same land. In the warmer portions of those three States, and indeed a little farther north, a second crop can sometimes be produced. The Agricultural Experiment Station at Manhattan, Kans., had fair success when 225 days elapsed between planting the first crop and digging the second, but a growing season of 195 days proved too short for two crops.

The second crop is grown by methods somewhat different from those employed with the main crop. Small potatoes from the early crop are extensively used for seed, and these should be planted whole (or with only a small slice removed), for when cuttings have been planted in August or September a poor stand has generally resulted.

It is best to allow the crop which is to furnish seed potatoes for the second crop to remain in the ground until the vines are entirely dead. However, the culls may be used even when the early crop is dug before complete maturity. To prepare these culls for prompt growth and to eliminate those too immature to sprout the small potatoes are exposed to the light in a shady place for several days or until they become greenish; then they are spread out on the ground in a single layer and a little fine dirt sifted among them, covered with straw or pine needles, and the bed kept constantly moist. "The potatoes will sprout earlier if before bedding them under the straw a small piece is clipped off one end and rejected."

Planting time varies from the last of July in Virginia to September in Florida. For the Gulf States, and others with similar climate, the usual time for planting the fall crop is the first half of August. Plant without ridging in furrows about 6 inches deep. In the bed select only the potatoes that have sprouted. Drop them in the freshly opened and moist furrow, cover at once with about an inch of soil, leaving a depressed row to be filled by subsequent cultivation. In covering with the hoe the man should walk in the row and thus compact it. Professor Massey recommends the use of a home-made coverer consisting of an ordinary plow beam and handles, with a crossbar in front, to which are attached two spiked teeth a foot apart; behind these teeth is a roller. By planting deep the moisture of the soil is made available to

the young plants, and by covering lightly prompt growth is insured. For the second crop an early variety should be employed.

The advantage of second-crop potatoes is their superiority in keeping qualities. In a warm climate potatoes dug in June or July can not well be kept without sprouting, and thus injuring their value for eating and planting, while the second crop, dug in October or November, can be kept perfectly through the winter and late into the following season.

Recently the claim has been made that second-crop potatoes excel ordinary potatoes for seed purposes. It is undoubtedly true that unsprouted second crop seed potatoes are better than sprouted potatoes from the main crop. This makes the use of second-crop seed popular in portions of the South where unsprouted seed potatoes are difficult to obtain. Recent experiments at the Kansas Experiment Station indicate a superiority for second-crop seed even as far north as Manhattan, Kans. There in 1890 second-crop seed produced a crop 27 per cent larger than main-crop seed of the same varieties; in the following year the excess was 70 per cent in favor of seed potatoes of the second crop.

Whether or not the continued use of second-crop seed propagated by means of culls results in degeneration seems at present an open question. Many successful growers have employed second-crop seed for a number of years in succession. Many of those who grow early potatoes for market use northern seed in spring to obtain potatoes for planting the second crop, which in turn is intended as seed for the next early crop. Thus the advantages of second-crop seed and of frequent renewal of the stock are secured.

SUMMARY.

(1) A rich, sandy loam, well drained and well supplied with vegetable matter is the best soil for the potato. Stiffer land may be improved as a potato soil by green manuring and drainage, and lighter soils can often be made sufficiently rich by the addition of green manures and fertilizers.

(2) Potatoes should not, as a rule, be grown continuously on the same land, but should be alternated with other crops. Barnyard manure may be freely used, but should as a rule be applied to previous crops in the rotation.

(3) If commercial fertilizers are used a mixture containing nitrogen in form of nitrate of soda, phosphoric acid as superphosphate, and potash as sulphate, and in which potash predominates, is recommended.

(4) Preparation of the land should be deep and thorough.

(5) Planting without ridging generally affords the larger yields, but a stiff soil and the desire for an extra early crop sometimes necessitate planting on ridges.

(6) The best time for planting depends on the climate of each locality; the planting should be so timed as to bring the period when the tubers are rapidly forming at a date when the average rainfall is ample.

(7) On mellow, well-drained soil deep planting (3 to 5 inches) is best,

especially when the season happens to be dry. For the early crop, or on stiff soil with a tendency to bake, the depth of planting may be decreased.

(8) The use of the harrow before the plants are all up and frequent shallow cultivation afterwards until the vines shade the land are advisable.

(9) Seed potatoes grown in New England in several tests proved superior to Maryland seed both in New England and in Maryland. However, the data seem insufficient to determine definitely the relative value of seed potatoes from different climates.

(10) Cutting the seed pieces a few days before planting appears to exercise no injurious influence, provided, of course, that the cuttings are carefully stored in the interim.

(11) The yield from planting the seed or bud end is generally greater than from the stem or butt end of the tuber. The eyes on the seed end are the first to germinate, and hence are especially important when an early crop is desired.

(12) Exposing unsprouted tubers in a warm place before planting hastens growth, but if continued until sprouts form (which are rubbed off) the yield may be considerably reduced.

(13) Experiments indicate that it is more important to cut the tuber into compact pieces of nearly uniform size than to so shape the pieces as to have a definite number of eyes on each set. No piece should be entirely devoid of eyes, and the majority of the seed pieces should be large enough to support at least two eyes and better three or more.

(14) At distances of 1 by 3 feet, and with seed tubers averaging 4 ounces, an acre requires of quarters about 15 bushels.

(15) The total yield increases with every increase in the size of seed piece from the single eye to the whole potato; this increase occurs both in the large and in the small potatoes, but chiefly in the latter.

(16) The gross yield of salable potatoes (large and medium) also increases with the size of the seed piece from one eye to the whole potato.

(17) The net yield of salable potatoes (found by subtracting the amount of seed potatoes and the yield of small potatoes from the total yield) increases with every increase in the size of seed piece from one eye to the half potato. The half potato affords a larger net salable crop than the whole potato on account of the excessive amount of seed required in planting entire tubers. Taking the average of many experiments it was found that for every 100 bushels of net salable crop grown from single eyes there were 114 bushels from 2-eye pieces, 131 bushels from quarters, and 139 bushels from halves, but only 129 bushels from planting whole potatoes.

(18) These results favor the use of halves as seed pieces if seed potatoes and crop are assumed to be of equal value per bushel, but when seed potatoes command a very high price quarters may be used to advantage.

(19) Large seed pieces afford an earlier crop and are less liable to result in a deficient stand or entire failure, which, in unfavorable years and poorly prepared soil, is sometimes the fate of small pieces.

(20) With judicious planting there is probably no necessity for reducing the number of stalks per hill by thinning.

(21) It is better to place in a hill one large piece than several very small ones of the same aggregate weight.

(22) Distance, variety, character of soil, and numerous other conditions are factors in determining the most profitable amount of seed. The distance allowed each piece should increase with the size of the piece, and should be greater with varieties with rank growth of vines and numerous tubers than for less vigorous varieties.

(23) Small potatoes can sometimes be used for seed with profit, in which case they should be planted whole. Leading growers are careful to select for seed medium to large tubers of good shape, and their example should be followed.

(24) In harvesting it pays to handle potatoes carefully, and this is especially necessary for early potatoes dug before the vines are completely dead, and while the skin is tender. Removing the largest tubers by hand, before growth ceases, does not necessarily reduce the yield, but is practicable only on small areas.

(25) Darkness and a low temperature are the primary requisites in the successful storing of potatoes.

(26) In warm climates a second crop can be obtained within one year by planting sprouted whole potatoes in midsummer.

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